MEMORANDUM OF POINTS TO BE COVERED BY MR. EDISON'S DEPOSITION IN THE MOLDED RECORD CASE.

The deposition is to be taken in both suits.

One suit is on the broad patent, 713209, describing the expanding or pressing process, and involves claims 2 and 3, the distinctive feature of which is contracting the duplicates out of the molds. The application was filed March 5, 1898; patent granted November 11, 1902, delayed by numerous interferences in the Patent Office.

The other suit is on patent 667662 describing the casting process by drawing the molten wax up into the mold from below. This patent covers, in claim 1, the making of a mold from a master having a greater pitch of the spiral record groove than the standard pitch. Claims 2 to 6 are also involved, which cover casting the duplicate in the mold and shrinking it out.

The defendant's process consists of pouring the melted wax into a mold surrounded by a jacket, maintaining the mold at a high temperature by steam in the jacket to drive off the air bubbles, and then admitting cold water to the jacket for setting the duplicate and shrinking it out. This process is described in general terms by the Macdonald patent 682991, September 17, 1901, filed November 3, 1900.

It appears that the idea of duplicating phonograph records, and particularly the idea of producing a matrix in durable material from which the record may be indefinitely reproduced, is one that E. had at the beginning of his phonograph work. In his English patent 1644 of 1878 he shows,

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in figures 59 to 62, different methods of duplicating. Fig. 59 is a "reindenting" device——a cutting duplicator. Fig. 60 is a device for rolling the record on strips from a roller of hardened metal having the record in relief and obtained by the electrotype or other process. Fig. 61 shows this metal record used for impressing another record on a cylinder. Fig. 62 shows a split mold of metal with the record on its interior for molding duplicates "with plaster-of-Paris or other suitable material". The Scribner Magazine article of April 1878 describes making a stereotype or electrotype copy of the record produced in tinfoil or other plastic material as a matrix to produce copies from. E.'s first U.S. patent No. 200521 (filed December 24, 1877) describes making a stereotype of the record, from which "multiple copies may be made expeditiously and cheaply by casting or pressing tinfoil or other material upon it". E. had in mind from the start the desirability of securing permanent matrices of phonograph records from which records could be duplicated as a thing which would be valuable after the processes of recording had been perfected so as to get good records. Records were not good enough in 1878 to warrant the commercial development of molding processes.

After taking up the phonograph again in 1885 or 1886 with records cut in wax surfaces, his mind returned to the desirability of providing for the duplication of records, and having experimented with the process of coating surfaces with metal vaporized in a vacuum (patent 526147, September 18, 1894, filed January 28, 1884), it occurred to him that this would be a good method of producing the conducting surfaces on wax records to enable such records to be electroplated and thereby secure a mold with the record

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in relief on its bore. He started to work on this subject about 1887 and very soon put special men upon the work. The man in charge of this work and who did the principal part of it at the beginning was Dr. Shulze-Berge, whose note-books (in German) are preserved. Under E.'s directions S-B. carried on elaborate experiments in plating wax phonograph records by vaporizing metals in a vacuum and in other ways, and from these records thus provided with a conducting coating S-B. made molds by electroplating and backing up the electroplated shell, and from the molds thus made, duplicate wax records were made. E. had, about 1887, made the invention of the phonograph blank or record entirely of wax, which lent itself peculiarly to this treatment (patent 382462, May 8, 1888, filed January 5, 1888). Many of S-B.'s molds are preserved and some of them will be put in evidence. The first molds made by S-B. were of records made with a chisel-point recorder in soft wax and cutting a deep groove. The experience had not indicated that duplicates from molds of this character could be shrunk out of a continuous mold, and we now know that it could not be successfully done.

Mem.— Aylsworth says he thinks that an experiment was made on shrinking these duplicates out, but that it resulted in such injury to the record that the split mold was tried.

Consequently E. proposed to split the mold so that it could be separated the instant the wax was hard enough to be self-sustaining and while still plastic enough not to injure the record (patent 484582, October 18, 1892, filed January 5, 1888). The records made with the split molds were defective on account of the knock produced by the fin at the split and also on account of the difficulty of making the grooves register. The methods of recording also were not

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at all perfect, although E was constantly working on that problem. In the summer of 1888 E. improved the recording and reproducing greatly by the invention of the curved-edge recorder and the ball reproducer (patent 430278, June 17, 1890, filed April 10, 1889), and by the invention of the soap blank (patent 430274, June 17, 1890, filed July 30, 1888). E. had molds made from records made with this recorder on this blank, and on experimenting with them found that the duplicates could be shrunk out of the molds without injury to the record surface when the mold was a continuous cylinder. Upon this he filed his caveat of October 26, 1888. From this time forward the experiments were conducted by S-B. under his direction with renewed vigor. S-B. made a large number of molds and made many duplicates from the molds. The duplicates were made from the molds in a number of ways which he had S-B. experiment upon extensively. One way was to pour molten wax in the mold around a core and shrink the duplicate out. Another way was to cause the molten wax to ~~xxxxxx~~ flow in at the bottom of the mold around a core, thus filling the mold, and subsequently shrinking the duplicate out. Another way was to dip the mold, producing a thin coating, which was backed up by wax cast in around a core and then shrinking the duplicate out. In the last case pressure from a hydraulic press was sometimes employed to press the dipped shell of wax outwardly against the record, but this was not found necessary. Another way was expanding a blank in the mold and afterwards shrinking it out, as described in the caveat. In connection with these experiments many different wax compositions were tried, both for the master records and for the duplicates, and the thing was carried forward to the point, before S-B. left the work in 1891, where ~~xxx~~ very satisfactory duplicate records could be produced. E. was,

Put in Caveat

Identify molds

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however, still working towards perfecting the recording, and the methods worked out by S-B., while giving good duplicates, involved a large percentage of imperfect duplicates, which made the process an expensive one.

S-B.'s work was continued by Albert Wurth, who worked for a while under S-B. W., under E.'s directions, continued to make continuous molds and to perfect the plating processes, and also continued to make duplicates from these molds. He made duplicates by the casting and dipping methods, but particularly worked up the details of the expanding method described in the caveat. In 1894 the process had reached such a high degree of perfection that I determined to see how many records could be made from the molds without deterioration of the record. Under my direction W. made upwards of a thousand duplicates from one mold in that year, bringing them to me from time to time for testing. The thousand duplicates appeared to be in all respects as good as the first, and there seemed to be no deterioration of the mold in any respect. I concluded, consequently, that these molds would last indefinitely. Since the record business of my Phonograph Company was almost entirely in musical records of one kind or another, I made a vast number of experiments in the perfecting of the recording of music so as to secure a higher class of record before putting out the molded record. Duplicates were being made by the cutting process, which was cheap and resulted in a very small percentage of imperfect records. It was cheaper than the molding process on account of the large percentage of imperfect duplicates, and this, together with the lack of perfection in recording, prevented me from bringing out the molded duplicates commercially. Miller began operating the cutting duplicating plant for the Nation-

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al Phonograph Company in May 1897 with originals for masters. In the fall of 1897 I determined to use the molded duplicates for masters and had Wurth make up a large number of molds for this purpose.

Molds

Mem.— Wurth began to make molds in quantity in December 1897. In June 1898 the duplicates were used as masters in the cutting plant. In May 1899 concert molds were made, and these were made in large numbers during the summer of 1899 for commercial work, the duplicates being used as masters for the cutting process.

The practice followed in molding blanks furnished no indication that records could be shrunk out of hollow molds without injury to the surfaces. When we began to make blanks wholly of wax in 1887 we cast them in iron molds around iron screwthreaded cores. We found it necessary, in order to get the blanks out of the molds after they were set, to coat the molds and cores with castor oil. Even then the surface of the blank had to be turned off with a cutting tool afterwards to give a surface sufficiently good for recording. We subsequently substituted brass molds, retaining the iron cores. These were smoother than the iron molds but still needed lubricating. This practice was continued in our Works down to 1895 or 1896, when we adopted our present method of casting blanks, in which the blanks are withdrawn from the molds while still very plastic. In this condition the wax composition is self-lubricating and can be drawn out of the molds without the use of a lubricant, but the surfaces are rough and have to be turned off. In 1888 and 1889 the Graphophone, which was the only competing talking machine on the market, was

Surface 352 417 Feby 4 '98

Graphophone v Cook

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provided with blanks made by coating paper tubes with a thin coating of soft wax. This machine disappeared from the market under the competition of my phonograph, but a year or more after the North American Phonograph Company, which was handling the phonograph business, failed in the summer of 1894, the Graphophone Company brought out a new machine, appropriating the features of my successful phonograph, including the curved-edge recorder and ball reproducer and the all-wax blank. The Graphophone paper-covered record is not adapted for the molding of duplicates.

The expanding process of my patent 713209, as well as the casting process of my patent 667662, were perfected by the experiments of Shulze-Berge and Wurth conducted under my direction, together with the dipping process as carried on by Shulze-Berge and Wurth and particularly described in Shulze-Berge's note-books. In 1900 Miller, who was in charge of my commercial duplicating plant, and Aylsworth, who was an expert on waxes obtained by me, carried the dipping process, on which Shulze-Berge and Wurth had experimented under my direction, to the further point that the entire thickness of wax required could be coated on the mold, and reduced the process to the point where the percentage of imperfect duplicates was so small as to make it cheaper than the cutting process. My recording and reproducing experiments had also brought me to a greater point of perfection, where I thought they warranted the putting of molded duplicates on the market, which included the large investment in molds necessary to furnish the great variety of subjects called for by the trade. This process was therefore adopted by me and put into commercial use in my factory. A plant having a commercial capacity was installed early in 1901, and throughout the year 1901 molds special-

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The duplicates did not give good reproductions, I was searching for the reason I found that

ly designed for this work were made in quantities and a large stock of duplicates was produced. The marketing of molded duplicates was begun early in 1902 and the sale of our cut duplicates was stopped.

Regarding shrinkage: I observed early in my experiments on making duplicates that a shrinkage of the duplicates resulted which produced a larger number of threads or turns of the record per inch than in the original from which the mold was made. This was more noticeable in the case of cast or dipped duplicates than in the case of the expanded duplicates on account of the higher temperatures employed. I determined early in the work to take care of this by making the originals and molds with a smaller number of threads per inch than the standard of 100, so that after shrinkage the duplicates would have ~~xxxx~~ 100 threads per inch, instead of taking care of the larger number of threads per inch by a change in the mechanism of the phonograph, which might have been done. Shulze-Berge and Wurth experimented elaborately on this subject under my direction, and determined the exact conditions of shrinkage, as appears by their note-books. This I did ~~xx~~ not regard as an obvious thing to do on account of the microscopic size of the record grooves with which we were dealing and due to other refinements involved in making records.

The Macdonald patent describes an inoperative process. Superheating does not overcome the objection of air bubbles.

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A. Theo E. Wangeman; 48 years old; works at Edison laboratory; started to work at Edison laboratory in spring of 1888; continued working there until June 15, 1889, when he went to Europe on phonograph business; returned to the United States in February or March 1890 and continued working in the laboratory until June 1890; from June 1890 to sometime in 1893 continued to work for the Edison companies, being located in New York but occasionally spending several days at the laboratory; left Edison's employ in March 1893 and did not return again until 1902, when he started again on phonograph business at the laboratory and has remained since.

During my continuous occupation at the laboratory from the spring of 1888 to June 1889 and from March 1890 to June 1890 I was employed as an experimenter on the recording of music for perfecting the recording of music, both vocal and instrumental, in the phonograph. I was occupied in this work in room 13. I was acquainted with the fact that Shulze-Berge was carrying on experiments in plating records and making metallic molds, and also in molding duplicates from these molds in various ways. The record cylinders which he used for plating in the manufacture of these molds were all obtained from my room and were mostly made specially for him either by myself or by Walter Miller, who worked there at the same time, and the duplicates which Shulze-Berge produced from these molds he would bring to my room and have me test them for scratch and for the running out of the thread and for warping. Shulze-Berge was carrying on these experiments in rooms on the second floor of the laboratory, while my room was on the third floor. I visited Shulze-Berge's rooms frequently and saw what he was doing, and I often conversed with him about the subject, both alone and in the presence of Mr. Edison.

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Nick Wiley was also engaged on the same experiments. His work particularly was plating in a bath. One of my first recollections is seeing Wiley take phonograph records and secure a conducting surface by covering them with plumbago and then plating on the cylinders in a bath different metals or a number of metals. At the same time Shulze-Berge was plating phonograph records with metals in a vacuum to secure the conducting surface, after which either Shulze-Berge or Wiley would plate the cylinders in a bath to secure a stiff coating. After a sufficient thickness of metal was obtained, the original record was removed from the mold, leaving a cylindrical mold with the record on its bore. At first these master records were removed from the mold by breaking the wax out or melting it out; then the mold was cleaned. For the taking of duplicates I recollect that the early work consisted in taking these duplicates with a mold which was split lengthwise into two parts or provided with one slot. I do not recollect how the duplicates were produced in these split molds, but I do recollect listening many times to duplicates made in the split molds and observing the knock produced by the slot, and also observing that in some cases the threads did not match properly. Later I recollect they did away with the slotting of the molds and removed the duplicate records from the molds by contracting them out. I recollect particularly discussing with Shulze-Berge the question of casting metal duplicates in these molds, particularly for use on the doll phonograph. This was brought up by my running across a table showing the contractions of different metals one day while examining some book in the library. The duplicate records which were being made in these molds right along and which were brought to me for testing were, however, made of wax. Some of them were made by casting in

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the molds around a core and then shrinking the duplicate out; others were made by dipping the mold in molten wax, securing a thin coating, and then backing this up with wax which was cast in around a core, and then shrinking out the entire record. In some cases pressure was applied to the inside of the wax cylinder before it was shrunk out by means of a hydraulic pump. I recollect that the water which was used for producing this pressure was ~~sometimes~~ heated.

About the fall of 1888 the duplicate records made by Shulze-Berge commenced to be fairly good in spots, although not wholly satisfactory. Before I left for Paris in 1889 Mr. Shulze-Berge had made some duplicate records which compared very favorably with the originals, and he had a number of these on a board which he tried over and over again in my room at various times because he regarded these as particularly good, and these were used for comparison with new ones, and he seemed to enjoy hearing them because they were so good. After leaving the laboratory in 1890 I saw nothing of the process of making duplicates, although on my visit to the laboratory and days when I worked here up to March 1893 I would be requested to listen to duplicate records to express my opinion as to how good they were, both duplicates and masters. I understood that Mr. Wurth was working on duplicating at that time, and he frequently showed me duplicate records, but I was not acquainted with the process which he was carrying on.

Regarding the curved-edge recorder, I was furnished with a number of these for the purpose of making musical records towards the end of the year 1888. Mr. Edison had been experimenting on this recorder for some time before that, and I might have tested one before this time, but I

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recollect that I received them for regular use in making records towards the end of 1888. I also recollect that before that time Mr. Edison frequently sent some of these curved-edge recorders up to my room for testing as to wear. I don't recall the process which was used for the manufacture of wax phonograph blanks at that time. It didn't come within the scope of my work.

Numbering pages in note books
Schulze Berge books
What's became of S B & Bailey

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Albert Wurth, son of Charles Wurth, twenty-six years of age; started to work for his father in the Edison Laboratory July 20, 1894; worked five or six months at that time; assisted his father in making duplicates from continuous molds; he prepared the rough blanks for duplicating and also carried on the duplicating operations; during that time he assisted his father in making about 1,000 duplicates of mold F; made the most of these duplicates himself, beginning at least with No. 47 ; some of the figures on pages 97 , 98, 99 and 100 of his father's note-book are his, and all of the figures on pages 101 to 103 are his. The purpose of making the thousand records was to see of the mold would wear out. Tests of the duplicates showed that the last were as good as the first, establishing the proposition that thw mold would last for an indefinite number of duplicates. At the same time he also assisted in making over 200 records of mold 54 with the same result. The method of making these duplicates he will describe, and one of the exhibits has a hollow core , a stopper, a glass tube and thermometer. His father's note-book was kept in consecutive order, and at the time the notes on pages 97 to 103 were made the notes now appearing on the preceding pages had been made; that is, by looking them over now they appear to be the same as they were then.

At the time he worked for his father in 1894 there were a large number of continuous molds with records on their inner walls in his father's room. About a week after making the last of these thousand or more duplicates of mold F, he left the Laboratory and did not return again to the Laboratory until November 10, 1897 , since which time he has worked continuously at the Laboratory in connection with the making of molds for duplicating records and helping his father in making diaphragms for experimental recorders and in taking records. When he returned to the Laboratory in November, 1897 , there were a number of larger sized duplicating molds which had evidently been made between 1894 and November, 1897 . An exhibit shows one of these molds. Thinks his father was making some of these molds when he returned, but there were others around which had already been made.

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These were molds for making six inch duplicates from masters taken on a 320 (2400) thread machine. The work of making these long molds was discontinued shortly after his return to the Laboratory. When he returned to the Laboratory November 10, 1897, his father was setting up phonographs to take small records for the manufacture of more small sized molds. One of the phonographs was provided with a contrivance for varying the pitch of the feed so as to reduce the number of record grooves per inch below 100 to allow for shrinkage in duplicating. (Look for it) Records were taken on these machines in the lecture room, and from these records we began the manufacture of a large number of molds. The first of these, number 1, Dance of Brownies, was put in the plating machine December 15, 1897. I attended to the plating of these records at that time, and have a record beginning December 15, 1897, showing the different cylinders that I plated. These master cylinders all had a somewhat coarser pitch than 100 threads to the inch, but just how much I do not recollect. We had eight of the plating machines running, and my record shows cylinders plated by all of the eight machines, the record extending from December 15, 1897, to December 17, 1898.

Mold F, from which the thousand records were taken, is described on page 7 of the Wurth note-book, also in the list on page 23. It is also referred to in Shulze-Berge's note-book under date of December 8, 1890. Mold 58 is described on page 13, also page 26, Wurth note-book. A memorandum of the duplicating taken from it appears on page 21 under date of November 24, 1891. Mold 75 appears to have had records taken from it under date of November 29, 1891, page 21; also in the list on page 26. Mold No. 1 (Dance of the Brownies) appears in the long records of molds under date of December 15, 1897. This is the first of the new small molds to be done at that time. This long record shows that molds of concerts were made May 23 and 24, and June 12 and 14, 1899, and that the regular manufacture of these concert molds was begun July 6, 1899. Mold No. 2, which is an exhibit,

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was made July 6, 1899. The concert molds were used at the start for making duplicates to be used as masters in the cutting duplicating operations at the phonograph works. Some of the small molds were used before that time for this purpose. My record of June 4, 1898, shows the mold "Whistling Girl, W. Miller, 24", which I recollect was made for this purpose from the record furnished by Mr. Miller, who had charge of the commercial duplicating. A similar mold, made July 29, and another one made August 3, were made for the same purpose. Molds for experimenting onthe new process were furnished to Mr. Aylsworth as early as June 11, 1900, two molds of that date marked "J. W. A." indicate that they were sent to Mr. Aylsworth. Another mold of September 1, 1900, in the gold-plating book is also marked "J. W. A." This book shows that we started on April 18, 1900, to make up a large stock of small molds which were used largely to make masters for cutting duplicating. The manufacture of molds from high speed records, especially for the new duplicating process, was begun on December 26, 1900, and was continued in January, 1901, such molds being made in large numbers, as appears by the gold-plating book. The molds which were manufactured beginning in December, 1897, were intended to make duplicates for the market, but these molds were commercially used only for making masters for the cutting duplicating process, because the record groove was not sufficiently coarse in pitch to allow for the larger shrinkage which takes place in that process, as compared with the expanding process, for which the molds were specially constructed.

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Walter Miller; age 33; Manager of the Record Department of the National Phonograph Company; began to work at the Edison laboratory in the spring of 1887; remained at the laboratory until, he thinks, sometime in 1893, when he started making phonograph records for the North American Phonograph Company in New York; continued with them until ~~xxxxx~~ they went into the hands of a Receiver, when Cleveland Walcott and himself bought out the plant of the North American Phonograph Company and started the firm of Walcott & Miller September 1, 1894; during the time he worked for the North American Company he was frequently at the laboratory; during his work in the laboratory from the spring of 1887 to sometime in 1893 he was doing experimental work on the phonograph of various kinds including duplicating records; left Walcott & Miller February 15, 1896; April 1896 became connected with the Phonograph Record & Supply Co. in New York; that Company sold out its business in March 1897; started to work for the National Phonograph Company in May 1897 duplicating phonograph records by the cutting process; during the period from September 1, 1894, when the firm of Walcott & Miller was formed, down to the time the Phonograph Record & Supply Co. sold out its business in March 1897, he was engaged in making phonograph records, both originals and duplicates, the duplicates being made by the cutting process; continued in charge of the mechanical duplicating plant of the National Phonograph Company until it ceased operations, which was after the Company began to ship out molded duplicates early in 1902.

When I began operating the mechanical duplicating plant in May 1897 we used masters which we bought from the United States Phonograph Company of Newark. This kept up for about two months, when we began to make our own masters under my direction, and I paid less attention to the dupli-

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cating plant, although I kept the general oversight of it. Later we also used as masters, duplicates pressed in molds by Wurth. I recollect particularly some songs of Johnson, such as the "Whistling Girl", "Whistling Coon" and "Laughing Song", which molds were made of, according to Albert Wurth's record, in June, July and August 1898. Following these we used the pressed duplicates largely for masters in the cutting process. Along about July 1899 we began to use concert size pressed duplicates as masters in the cutting process, and we had a large number of concert molds made, and the duplicates pressed in these molds were used as masters for making concert records and in a small way for making small records.

The present dipping process was experimented on by Aylsworth and myself beginning about 1899. We first took some of the molds which Wurth had in stock for our experiments, and afterwards had Wurth make special molds for us.

When in the laboratory between the spring of 1887 and before going to work for the N. A. P. Co. in 1893, he recollects that Shulze-Berge was carrying on experiments in duplicating records. He recalls seeing Shulze-Berge coating the records by vaporizing metal in a vacuum; also recollects seeing the molds, and also recollects seeing many of the duplicates and listening to them. He doesn't recollect seeing the process of molding carried out. The duplicates made by Shulze-Berge seemed to be very fine, and, as he knows the subject now, they must have been shrunk out of continuous molds because they had no knock which would be produced by a fin if made in divided molds.

Work on the Miller and Aylsworth process was carried on at Aylsworth's laboratory at his house. The construction of a commercial plant at the Edison Works for car-

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rying on the process commercially was begun late in 1899, and a plant having a capacity of 3000 duplicates a day was completed sometime in February 1901. I recollect we were about ready to start when Mr. Edison left for Florida that year. In March 1901 the construction of a larger plant with an intended capacity of 20,000 duplicates a day was commenced. A large stock of duplicates was made during the year 1901, and early in 1902 they were put on the market. We did not go on the market until we had a large variety of selections, so as to be able to meet the demand without furnishing other than molded records.

My recollection regarding the bringing out of molded duplicates by the Graphophone Company is that they were not on the market, at least in quantity, until after our records were on the market. The first of these I saw were shown me by Mr. Barkerlow of the firm of Barkerlow & Kent, dealers in Graphophone as well as Edison records, and these were the first he received. He brought them up to the National Phonograph office in New York where I was and showed them to me as a new thing, and this I recollect was a month or so after our molded records were on the market.

The stock of molds which Wurth had on hand before he began to make special molds for our dipping process, were not used by us because the speed was too low, being 120 instead of 160, which was the speed we determined on, and also because the masters from which the molds were made were not coarse enough in the pitch of the record groove to give duplicates having 100 threads to the inch when the duplicates were made by the dipping process. Wurth had a number of feed-screws for phonographs which were constructed of different pitches for getting masters of a coarser pitch than 100 threads to the inch, and he also had a device which he put on the 100-thread phonograph for shrink-

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ing the feed arm back by means of an incline so as to give him any pitch he desired, the incline being adjustable so as to give any variation from 100 threads per inch desired. When Aylsworth and myself began our experiments we made masters with the different feed-screws which Wurth had, and then determined the number of threads per inch which the duplicates from these masters would give. In this way we determined the pitch which the master would have to have in order to give 100 threads per inch on the duplicate. This we found to be $98^2/3$ threads per inch.

Graph Co Conglomerates molded used this summer- copying way used by N.P.Co & changing method of manufacture

Molding Plant
Graph Plant 85-95

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J. W. Aylsworth; age 34; started to work in Edison's laboratory in the fall of 1887 and continued until about the first of January 1891; in January 1891 took charge of the filament plant of the Edison Lamp Factory, and remained in that business until ~~sometime in~~ September 1894; then went into business with Jackson, manufacturing filaments on our own account, and remained in that business until ~~about~~ May 1898; during this time I did work for Mr. Edison at his iron mines, and also I think about ~~1894~~ June 1895 I was retained by his Phonograph ~~Company~~ Works as an expert in waxes for consultation with them as to their wax mixtures; previous to that time I had been consulted frequently on the same matters, but without salary; during one part of this period I spent several weeks at the laboratory experimenting on X-ray apparatus, and our firm, Aylsworth & Jackson, took up the manufacture of tungstate of calcium and fluorescent screens for Mr. Edison's ~~xxxxxxxxxx~~ fluoroscope; after leaving Jackson I built a laboratory (Fall '97) in connection with my house at East Orange, which was also being built at that time, and started in on experimental work; the experiments of Miller and myself regarding duplicating ~~xxxxxxxxxx~~ phonograms were carried on at my laboratory, and after the process was taken up by the National Phonograph Company and a plant built for carrying it out, I ~~entered the employ of the National Phonograph Company as foreman~~ took charge of that plant sometime early in February 1901; my employment began with the building of this plant, the putting in of which I superintended, and continued afterwards in charge of the plant itself; I remained in charge of this plant about 4 or 5 months, when I took up work on the storage battery for Mr. Edison in his laboratory, continuing however a general oversight of the duplicating plant; my principal work since then has been in connection with the storage battery,

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in which work I am now employed, although during all this time I made many wax experiments for the Phonograph Works.

During the time I was employed in the laboratory between the fall of 1887 and the first of January 1891 my work was principally on wax experiments for phonograph blanks and records. I was acquainted with the experiments which were being carried forward by Shulze-Berge and Wurth in the manufacture of molds for producing duplicate records. One of my earliest recollections of Shulze-Berge's experiments is that he was experiencing some difficulty in plating the records, and he wanted to try different kinds of waxes. I examined his plating apparatus in which the record was mounted in a glass receiver connected with an air pump, and noted particularly the ingenious method of rotating the record by a rotating magnet placed outside of the glass chamber and acting on an armature inside so as to not have any mechanical connection passing through the glass. I furnished him with a number of different wax compositions for his purpose, and also made blanks for him on which records were to be made for plating. I saw a number of molds at that time, and also saw him molding duplicate records in the molds. These molds were made substantially as they are made at the present time by first plating the wax record with a metal vaporized in a vacuum chamber to secure a conductive coating for the plating process, and then plating copper upon this metal coating to form a stiff shell. This shell was then backed up by metal so as to give it strength. The duplicates were made by Shulze-Berge in several ways. Some of them were made by pouring the wax into the mold around a core and then shrinking the duplicate out by putting the mold in an ice-box. Another way he had was to dip the mold in a molten wax composition, securing a thin coating both on the outside and inside, and

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then he subjected the interior coating to hydraulic pressure from a pump, and subsequently backed up this coating with a filling of paraffin poured in around the core, after which the core was removed and the record was shrunk out by putting the mold in an ice-box. Subsequently he determined that the pressure was unnecessary, and the duplicates were made by casting the paraffin backing in around the core without the preliminary pressing. He made many of these duplicates in room 14, in which I worked. The hydraulic press was located in this room and I was using it there for other purposes.

I assisted Shulze-Berge in some instances in making these duplicates. I recall later in a general way the work done by Wurth in making duplicates by the expanding process. I saw him carry out this process a number of times, and furnished him with blanks of special wax from time to time so that he could see the differences in effect which would be produced by differences in wax composition. I recollect that Wurth made a large number of continuous molds for taking duplicates, many of which I saw. Looking at the Shulze-Berge molds backed up with a fusible alloy, I recognize these as molds of the character which Shulze-Berge had. The Wurth molds, which are also in evidence, I recognize as molds of the character which Wurth had.

In 1899 when Miller and myself began the development of the dipping process, we had in mind the carrying forward of the dipping process which Shulze-Berge had employed by providing means which would enable a record of a sufficient thickness to be molded so that it could afterwards be reamed out without requiring any backing. This process we carried forward to a state of such completion that the Phonograph Company took it up and adopted it for

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its commercial manufacture along towards the end of the year 1900. A plant having a capacity of 3000 duplicates a day was built early in 1901, and during the year 1901 we accumulated a large number of duplicate records with a view of having a stock sufficient to warrant putting them on the market. They were put upon the market early in 1902.

In the experimental work of Miller and myself we used molds secured from Mr. Wurth out of the stock of molds he had on hand, and we also had him make special molds for our purpose. Some of these, "My Suzanna" and "Just Like a Girl" which appear on Albert Wurth's book under date of June 11, 1900, I recollect. I also recall the special molds made from high-speed records which Wurth made for us and which appear on Albert Wurth's book under date of December 26, 1900. At that time we had decided to bring out the duplicates with a speed of 160 revolutions. Beginning in January 1901 Wurth manufactured molds in quantity for commercial use in our dipping process, as appears by Albert Wurth's book. We did not use for commercial purposes the stock of molds which Wurth had on hand, principally for two reasons: the masters were made at a speed of 120 revolutions and we had decided on 160 revolutions, and also the masters did not have a coarse enough pitch to the record to allow for the shrinkage which took place with our dipping process, the shrinkage with the expanding process employed by Wurth with these molds being somewhat less. Wurth's molds were about 99 threads per inch, whereas we needed about $98\frac{2}{3}$ threads per inch.

At the time I entered the laboratory, Mr. Edison was making his blanks entirely of a wax composition as distinguished from wax mounted upon paper or other foundation. The blanks were first made by casting in iron molds around iron cores, castor oil being rubbed on the molds and cores

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to facilitate the removal of the blanks. Subsequently brass molds were employed, still using the iron cores, but the lubricating material was still found necessary. I supplied a substitute for the castor oil, which was better in that it made the turnings and broken blanks available for remelting. In casting the blanks, after the material had set but while still quite hot, the core, which was screw-threaded, was given a half turn to loosen it and the mold allowed to stand a short time longer, when the blank could be drawn out. This practice was continued in the Phonograph Works until about 1895 or 1896, when the present practice was adopted, in which the blanks are drawn out of the molds while still in a plastic condition. No lubricant is put in the molds, because the wax when in this condition of heat is self-lubricating. The surfaces of the blanks are not such as would be required for recording, but the blanks have to be turned down to give a proper surface. There was nothing in the manufacture of blanks at the time of the Shulze-Berge experiments on duplicating which would lead one to suppose that a record could be contracted out and removed from a continuous mold with the perfect surface which would be required for a duplicate. I recall that in the manufacture of blanks, that ~~as soon as~~ molded the castor oil was used, the mold would have to be cleaned, because a part of the surface of the blank would stick to the mold. Of course castor oil or other lubricant could not be used in molding duplicates, because it would interfere with the perfection of the impression and would also soften the surface.

I recall the fact that the graphophone as it was on the market in 1888 and 1889 employed a record blank made of a paper tube coated with a soft black wax like ozocerite. A blank of this character could not be formed in a mold, or

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if so formed could not be shrunk out of a mold. When the graphophone reappeared on the market after the failure of the North American Phonograph Company it employed an all-wax blank.

It is my opinion that ~~xxxx~~ masters made with chisel-point recorders such as Edison used before bringing out the curved-edge recorder in 1888 could not be successfully employed for the making of molds from which the duplicates would be shrunk out by contraction. It is my impression that some of the early molds made by Shulze-Berge were made with masters of this kind and that it was found impracticable to shrink the duplicates out of the molds without injury to the record surface. To overcome that defect the split molds were used, but these were replaced by the continuous molds after the curved-edge recorder was employed.

My recollection is that when the National Phonograph Company put the molded duplicate on the market early in 1902, I had heard only a month or two before that the Graphophone Company was putting out a molded record, and my opinion at the time was that that Company had heard that we were to bring out a molded record and had rushed on the market with a limited stock so as to be ahead of us. The talent employed by the National Company was also employed by the Graphophone Company and kept traveling back and forth, so that what was being done in one factory was known in a general way in the other, and we learned that the Graphophone Company was making molded records long after we had begun to make up a large stock of these records for the market.

May 6 1903 demonstrates operativeness of pt Edison patent.

With own compositions duplicates may have coarser thread than mine

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